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Flexible graphene solution gated field-effect transistors for neuroprosthetics

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Tremendous efforts have been made in the last decades to study the interface between electronics and nerve cells, aiming at the development of neural prostheses. However, the currently available existing sensors such as MEAs and silicon solution gated field-effect transistors (SGFETs) suffer from several limitations, such as high intrinsic noise, poor stability in the harsh biological environments, and large mechanical mismatch to brain tissues. A promising alternative are graphene based SGFETs [1]. They offer a high chemical stability, biocompatibility, low electronic noise as well as high transconductances and thus high sensitivities [2], and could be integrated in flexible substrates. It has already been shown that graphene SGFETs fabricated on rigid substrates can be used to detect the electrical activity of electrogenic cells in in-vitro cultures [3]. However, in order to perform in-vivo measurements it would be desirable to integrate graphene SGFETs on flexible substrates in order to improve the transistor-tissue contact and to reduce tissue scarring.

In this work, we present the fabrication of graphene SGFETs on flexible polymer substrates using high quality CVD graphene and characterize their performance in electrolyte in detail. We also compare their performance to graphene SGFETs on rigid substrates and show that the flexible devices show similar transconductances up to several mS/V which makes them a promising platform for biosensors and bioelectronics. In electrolyte Hall-effect measurements are used to measure the charge carrier mobilities in the graphene, which are comparable to state of the art CVD graphene transistors. We will also report on the electronic noise of the transistors, revealing 1/f noise in the relevant frequency range of operation. Our long-term stability study confirms that the flexible devices are suitable for in-vivo measurements. Finally, we will conclude with the demonstration of cell recordings using these flexible arrays of graphene SGFETs.

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